A Collaborative Geodesign Approach for Integrating Local and Technical Knowledge in Establishing Land-Use Planning for the Border Town Comprehensive Plan

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Abstract

This article presents an original approach to comprehensive planning for supporting decision-making processes in the land-use planning of border town which integrates a set of frameworks and methodologies into technologies based on the use of geospatial information. The technologies embrace the domain of planning support systems, whose urban planner is based on the Geodesign framework. The purpose of this study was to develop a practical framework for Geodesign process to support the spatial planning process in practice. In this paper, a land-use suitability analysis (LUSA) method is proposed and demonstrated for the location requirements of the development and use of land. The study uses the Ban Lak Taeng Border Checkpoint Comprehensive Planning Project (a border checkpoint between Thailand and Myanmar to promoting cross-border trade and tourism, which is located in Wiang Haeng District, Chiang Mai Province, Thailand), as the research context for examining the ways that Geodesign was promoted the practical application. This Geodesign enhanced collaborative planning processes, built knowledge of natural and production systems at the urban landscape scale, and integrated consideration of feedback from multiple performance criteria into an adaptive and iterative process of land-use planning and design. The study describes the development and application of the Geodesign system used in the land-use planning process and offers important insights into how the system contributed to the collaborative stakeholder engagement, informed stakeholder decision making, and enhanced the comprehensive plan outcomes.

Keywords:
Planning Support System (PSS), Geodesign, Spatial indicators, Land-Use planning, Border town

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1. Introduction

1.1 A spatial decision support system for land-use planning

Land-use planning for urban development has become increasingly important and challenging due to rapid urbanization, urban land shortages and the conflicting goals in achieving economic growth, social equity, and environmental protection, especially border town areas. Urban planners and local decision makers often encounter the problem of having to deal with situations involving complex decisions (Witlox, 2005, pp. 437–445; Wang, Shen, Tang & Skitmore, 2013, pp. 70–80). Specially in developed areas, many different stakeholders such as governments, residents, and developers are involved in the allocation of land. As urban land use planning becomes increasingly difficult due to increasingly complex urban systems and large amounts of geospatial data and information involved (Katpatal & Rama Rao, 2011, pp. 65–76), planners need new sharp tools to equip themselves for meeting the growing technical requirements in planning practices (Coppola, Ibeas, dell'Olio & Cordera, 2013, pp. 153–165). Geodesign has become a buzzword in the past five years although its main origin goes back to the late 1960s, with the publication of McHarg's book Design with Nature (McHarg, 1969). Carl Steinitz's book "*A Framework for Geodesign: Changing Geography by Design*" (Steinitz, 2012) comes at a prime time since scholars, designers, and GIS (geographic information system) professionals have been intrigued to understand and explore this new trend. It is the geo-visualization and integration of multiple information types coupled with rapid and iterative quantitative modeling that makes Geodesign unique and offers so much promise for public engagement (Slotterback et al., 2016, pp. 71–80; Srivanit, 2016, pp. 53-60; Htut et al., 2016, pp.35-42).

Regardless of the particular genesis of the term, Geodesign can be characterized by three facets (Slotterback et al., 2016, pp. 71–80). First, the geography within Geodesign is illustrated in its relation to processes and forms on or near the Earth's surface, accomplishing what Steinitz (2012) calls "*geography by design.*" Second, the design in Geodesign is about "*sketch*" and "*simulation*", accomplished through the "*technology of design*" (Goodchild, 2010, pp. 7–22). Third, the Geodesign is characterized by social and process dimensions, as it incorporates scientific knowledge, integrates with human decision-making, and allows decision makers to enact the pattern-process-design relationship (Dangermond, 2010, pp. 502–514; Goodchild, 2010, pp. 7–22; Nassauer & Opdam, 2008, pp. 633–644). This last facet reveals a key prospect for application and further development. In particular, the Geodesign is acknowledged as a means of simulating impacts within geographic contexts (Flaxman, 2010) and decreasing the cycle time of participatory design processes (Dangermond, 2010, pp. 502–514), by facilitating an efficient process of proposition-disposition for design ideas (ESRI Press, 2013; Lyle, 1985, pp. 7–13). This process allows designers – whether expert or lay, acting independently or in a collaborative mode – to engage in an iterative process of pursuing scenario proposition and disposition (Lyle, 1985, pp. 7–13) toward the realization of land-use planning for the comprehensive plan.

1.2 Formation of a framework for Geodesign

Thus, the development and application of a Geodesign framework is emerging as an important evolution of earlier innovations in planning support systems (PSS) and public participation geographic information systems (PPGIS). These earlier approaches placed significant emphasis on the technology, analytical capabilities, and the support of decision-making, while highlighting the prospects for their use in public engagement processes (Geertman & Stillwell, 2003, pp. 3–23; Klosterman, 1997, pp. 45–54; Obermeyer, 1998, pp. 65–66). Building on this prospect, the potential of Geodesign is more fully integrated with technology and decision-making processes, producing better projects and outcomes for the environment and communities. This study focuses on the application of Geodesign, drawing deep insights from practical use and offering evidence as to its effects in decision making processes for the comprehensive planning project that involves varied landscape conditions, diverse community perspectives, and myriad environmental, economic, and social concerns. This study describes a collaborative process that is intended to engage participants in a joint search for information. Thus, Geodesign in collaborative processes can accomplish this kind of engagement by supporting group processes that utilize and integrate multiple geo-data sources to inform planning and design. Interaction among diverse people in collaborative processes facilitates communication, allowing participants to learn from each other, and ultimately accomplishes "*collaborative science*" (Bentrup, 2001, pp. 739–748; Mandarano, 2008, pp. 456–468; Slotterback et al., 2016, pp. 71–80). This process allows the continual proposition and disposition of alternative planning scenarios. As a result, participants can iteratively explore the tradeoffs and synergies, inherent in land-use design.

2. Materials and Methods

2.1 Study Area

Of the 77 provinces in Thailand, 32 provinces share a common border with four-neighboring countries (a river border with Lao People's Democratic Republic and a land border with Cambodia, Malaysia and Myanmar) with a total length of 5,582 kilometers, which are distributed in ten provinces next to Myanmar with a length of 2,400 kilometers. Cross-border trade has been inter-generationally carried out by local inhabitants gradually evolving from a very informal manner to become the more formal system as perceived today. The Department of Foreign Trade, Thailand defines cross-border trade as all forms of trade or exchange of goods transacted through border checkpoints by both sides of local people or traders, who reside in provinces or communities along the border. There are broadly three factors contributing to dynamic cross-border trade in the context of Thailand consisting of cross-border and regional infrastructure linkages, bilateral and regional trade agreements, and regional trade facilitation initiatives (Krainara & Routray, 2015, pp. 345-363).

The following analyses on the foreign trade through customs houses in the Northern Region of Thailand uses the available time series data of 10 years from 2007–2016. Regional economic integration leads to closer interdependence within the Greater Mekong sub-region (GMS), especially for trade and commerce.

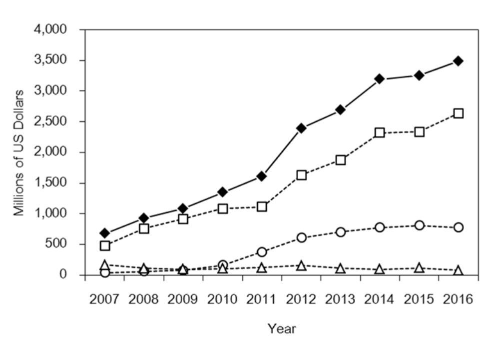


Figure 1. Foreign trade through customs houses in the northern region of Thailand from 2007 to 2016. (Modified from Ministry of Finance, Thailand, 2016)

Fostered by both geographical adjacency of structural differences and the above-mentioned contributing factors, coupled with the advancement of information technology, particularly the Internet and mobile phones, local and regional cross-border trade has shown a rising trend. The aggregate total cross-border trade in the Northern Region of Thailand gradually increased from 677.1 million US dollars in 2007 to 3,489.3 million US dollars in 2016 (see Figure 1). The top 5 products exported to Myanmar through Maesod border checkpoint were energy drinks, motorcycles, granulated sugar, diesel and benzene oils and consumer goods (Bank of Thailand, 2016). As a result, cross-border trade growth may somehow contribute to regional development as both urban and rural people including the poor along the border regions between Thailand and neighboring countries can also benefit from trade, as well as accessing a variety of products.

The findings of this study come from the Lak Taeng Border Checkpoint Comprehensive Planning Project located in Piang Luang Subdistrict (Tambon), Wiang Haeng District which is one of 71 border checkpoints across Thailand which, located in the northern part of Chiang Mai province (located at 19°41'23.04" N Latitude, 98°37'31.43" E Longitude) (Figure 2). The town lies near the Thai-Myanmar border with Shan State, Burma. This check point was officially announced to be the border trade since May, 1998. However, the Chiang Mai Governor ordered to restrain the migration and commercial activities at this point because of national security reasons in April, 2002. Presently, the import and export cross-border trade at Shan State disappeared. The Lak Tang check point is an important strategic area of Chiang Mai province and should be reconsidered to develop and support as the permanent crossing point for using the potential border trade zone. Thus, the Department of Public Works and Town & Country Planning (DPT) of Thailand assigned the institute of consulting research, which studies the impact of Lak Tang check point in term of border town comprehensive planning. The distance of Muang district and the check point is 177 kilometers within 3 hour's drive by using Highway No. 107 (Mueang Chiang Mai District to Chiang Dao District) and Road No. 1178 (Chiang Dao District to Wiang Haeng District).

Regarding transportation, the project area can be reached by Highway No.1332 (Wiang Haeng District to Ban Lak Tang) as the main road passes through neighborhoods, commercial and residential areas as well as significant places such as Piang Luang School, which is also located on this roadway. Additionally, Highway No.1332 connects between Highway No.1178 from Wiang Haeng District and Lak Tang Border Checkpoint in Ban Lak Tang along with many minor and collector roads. For land use in Piang Luang Sub-district, nowadays, most of the areas are agricultural and residential lands. Most of the size of land parcels in this area are about 25 rai (or 40,000 square meter). Therefore, initiative approaches for vacant land development in agricultural suburban and residential zones are essentially needed in order to be ready for serving urban growth along with planning direction. In this concern, urban planning is systematically arranged to control urban sprawl. In terms of building use, it can be classified according to its use into 7 categories based on the DPT of Thailand including; residential, commercial, industrial, agricultural, religious, educational, and Lak Tang Border Check Point buildings (Figure 3).

Figure 2. Location map of the study area

Figure 3. (Left) Piang Luang village located in the mountain ridge and (Right) Piang Luang temple with ancient Tai Yai-style Vihar (place of worship) stands out. (Author, 2016)

Figure 4. (Left) Tai Yai/Shan social and cultural, and (Right) the community market at Ban Piang Luang on Saturday of each month and weekly. (Author, 2016)

For economic growth trend and projection in the next 20 years once the Lak Tang Border Checkpoint will be opened, it is believed that the economic value will reach 60,000 million baht by 2035 which will provide the opportunity for trade and investment. Regarding social characteristics in Piang Luang Sub-district, this area has the richness and diversity of ethnicity, race and culture living together in harmony including Tai Yai, Tai Yuan, Tai Lue, Haw, Karen, Lahu and Lee–sor. Furthermore, there are a great number of traditional and cultural tourism resources derived from a combination of ethnic groups in the area. The considerable traditions include Poy Sang Long Festival, Poy Tien Festival and Poy Som Tor Festival that more this area a highly multi-cultural society (Figure 4).

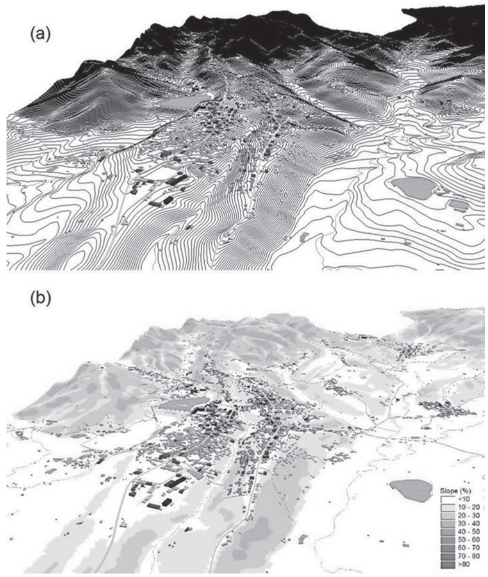


Figure 5. The settlement of large village of Piang Luang in (a) the mountain ridge and (b) high terrain. (Author, 2016)

This area has some economic and tourism activities where could be an interesting ASEAN border trade location in the future. The project is an effort to plan the prospects for the balanced of urban development and environmental values in a 22 square kilometer with more than 6,248 inhabitants, according to the population census results of 2016 (Figure 5). The population number is expected to reach about 16,660 in the next 20 years or in 2035. The project engaged two communities (Ban Piang Luang and Ban Mai Ma Ka Yon), including representatives of local, state, and federal agencies, extension and educational institutions, agricultural producer organizations, and environmental advocacy organizations.

2.2 Methodology

2.2.1 Prospects for integrating Geodesign and collaboration for land-use planning

Geodesign can easily be considered an outflow or evolution of earlier support of decision-making and participatory GIS applications. Moreover, Geodesign is characterized by social and process dimensions, as it incorporates scientific knowledge, integrates with human decision-making, and allows decision makers to enact the pattern-process-design relationship (Dangermond, 2010; Goodchild, 2010, pp. 502–514; Nassauer & Opdam, 2008, pp. 633–644). Integrating expert and "*local knowledge*" occurs as participants communicate their own perspectives and respond to those of others. The Geodesign framework consists of three main modules: land information database, planning and policy control mechanism, and the model of land-use suitability analysis (LUSA). This framework was conceptualized and developed based on the reality of land use planning in urban renewal. The whole process of the framework development (both conceptual and practical) is shown in Figure 6.

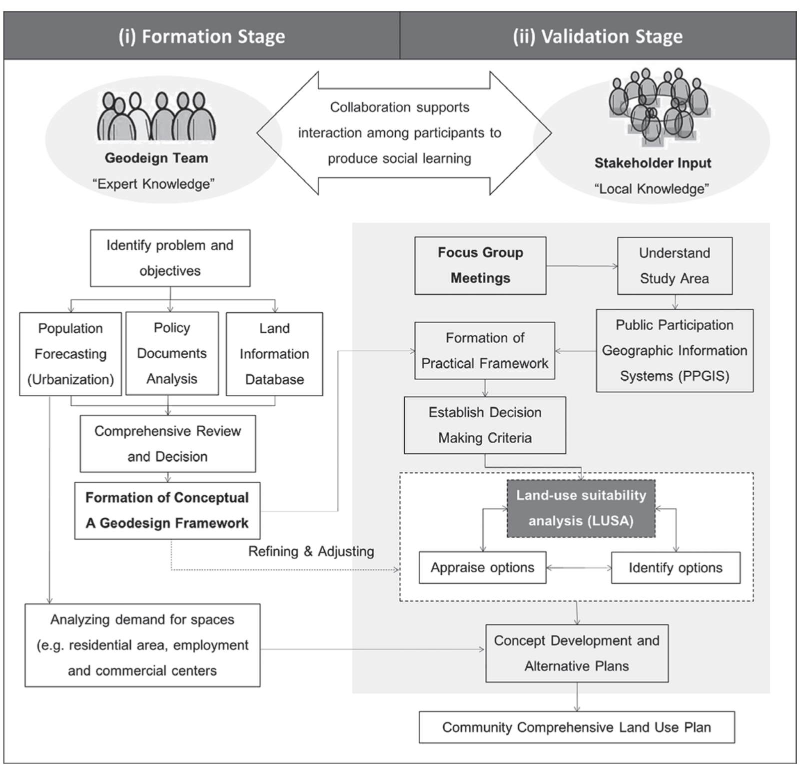


Figure 6. A Framework for Geodesign process structure. (Source: Author, 2017)

2.2.2 Development of practical framework for Geodesign process

After a framework for the Geodesign process was developed to support the planning process in practice, this practical framework consists of three main tasks as follows:

First, key factors affecting land-use decision making in urban land use planning are identified and 20 of them are quantitatively examined from five perspectives of land attributes: being inherent/physical, locational, social, economic, and environmental. The details of raw spatial data are shown in Figures 7. Some of the raw data could be obtained from government offices or relevant institutions, for example topography, soil types, vegetation, and geology. These spatial maps can be constructed by using GIS, a digital mapping system. With this framework, the spatial data were processed to provide the adapted data for LUSA. For example, creating the map of slope and elevation was derived from topographic maps; the euclidean distances between land sites and main public facilities were calculated based on the location map of public facilities to the measurement of levels of spatial accessibility of facilities (for example, a well-connected road network, and accessibility to public hospitals) (Figure 8).

Second, the criterion-value generation model and suitability of the assessment model are designed and built for LUSA in land development and conservation areas. The planning and policy control mechanism is a set of assessment criteria and their weighting for LUSA. The mechanism is built according with a literature review, document analysis, and expert opinions from planning practitioners. After the criteria of land-use suitability were finalized, the weighting for each criterion were determined by focus group meetings. The meetings were convened and facilitated by the authors and included presentations by other experts, including those from the participant groups. The focus group meeting with invited stakeholders included two sessions: the first session was the decision making group decision making by six experienced planning practitioners (the chief district officer, the mayor of municipal government, local planners, transportation and infrastructure engineers) and the second session, comprised of other participants (local developers and residents living in the studied district), joining the focus group for further discussion on weighting scoring for the spatial criteria (Figure 9). The weighting of each criterion was calculated by a simple ranking method, which arranges weight in order to be a preference for the decision maker. This method required the decision making agents to specifying their preferences with respect to the evaluation criteria (Srivanit & Selanon, 2017, pp. 49-60). Also, the method was created to deal with complex decisions, and then was refined and developed to apply to the decision making group. The spatial multi-criteria evaluation technique was a geoprocessing of the LUSA model created by using the spatial analysis application in a GIS software. Finally, a land-use suitability map for urban development was generated based on opportunity and constraint criteria (Figure 9).

Third, the land-use suitability map created from this study can support the particular process of land use planning, and they can be used as a reference for land-use decision making or planners. The suitability levels of the sites designed for alternative arrangements of land classification in accordance with six main types of land uses as follows: the low density residential zone, the middle density residential zone, the business and commercial zone, the industrial zone, the government and institutional zone, and the open space in a border town comprehensive plan which are defined and considered for land-use suitability grading. The process of searching for and communicating about information over time results in social learning, and the social learning process enables decision makers to come to a consensus for action. By allowing users to integrate multiple sets of geographic information in the generation of alternative scenarios for land use change, the realistic visualizations of change scenarios was generated, and estimated impacts of alternative scenarios on land-use planning for the border town comprehensive plan.

2.2.3 Collaborative Geodesign in practice

A Geodesign framework is systematically built for using spatial multi-criterion evaluation (SMCE) and GIS to enable planners to easily understand the rationale and to encourage them to follow this framework as a guideline for sustainable land use planning. The approach and workflow of establishing geo-information data sets are described, and a more open environment for user customization is provided through changing the criteria of land-use suitability by users. More importantly, the communication among planning practitioners and other stakeholders of local spatial planning is achieved by conducting interviews and focus group meetings at the beginning and also during the whole process of this research. The group met over 10 months in two half-day meetings focused on urban land use planning and designing for the border town comprehensive plan.

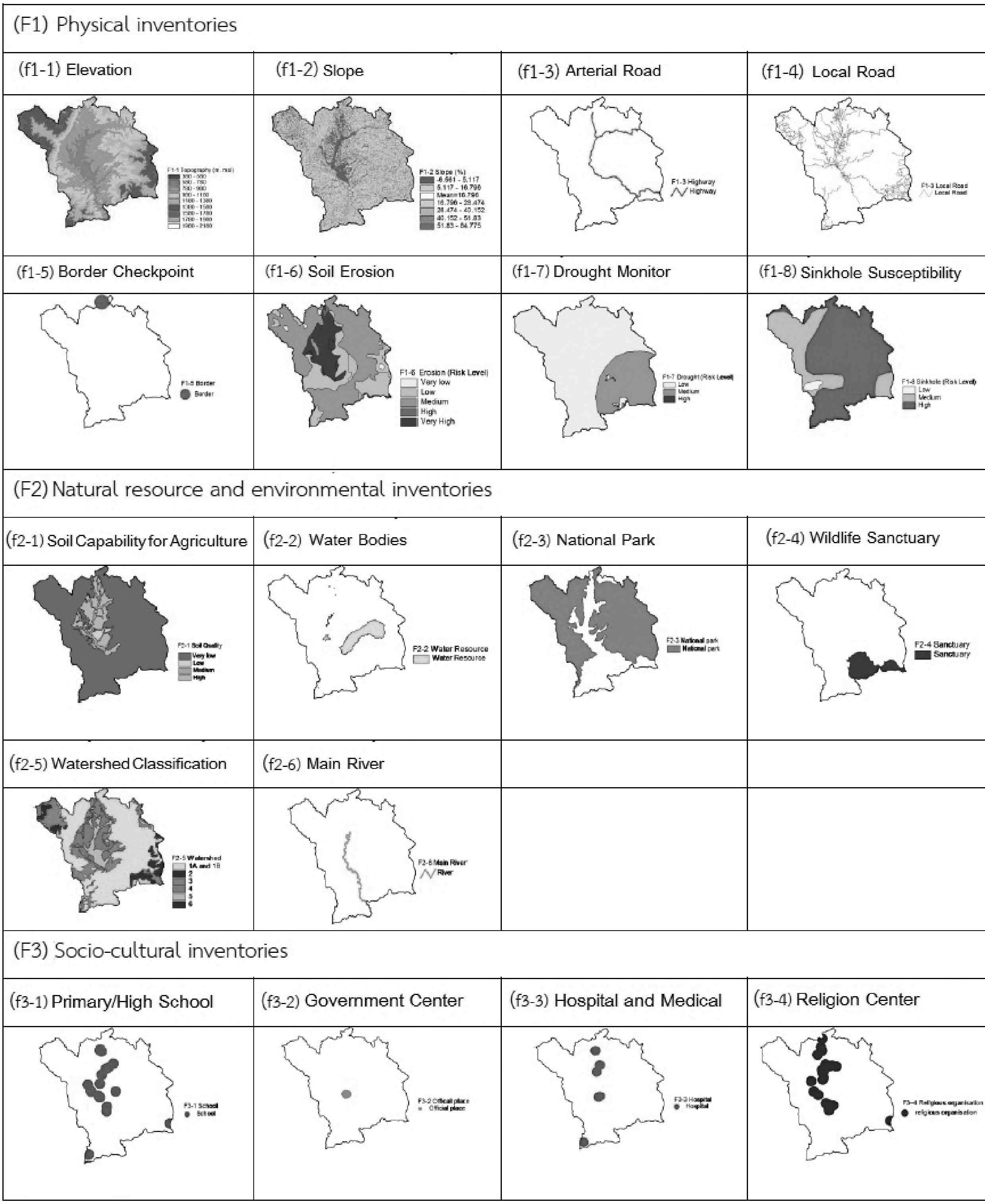


Figure 7. Spatial criteria of land-use suitability in the Wiang Haeng District

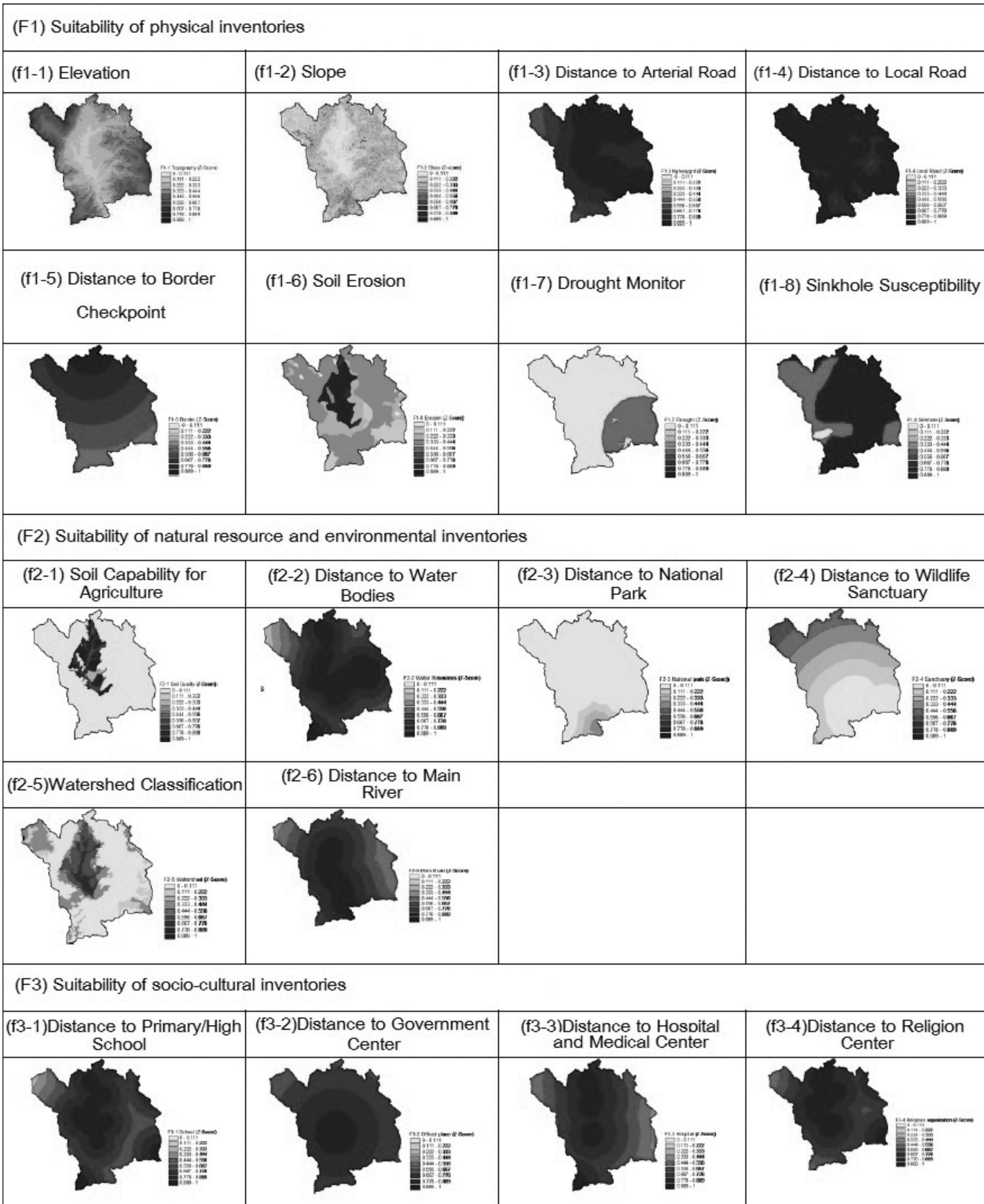
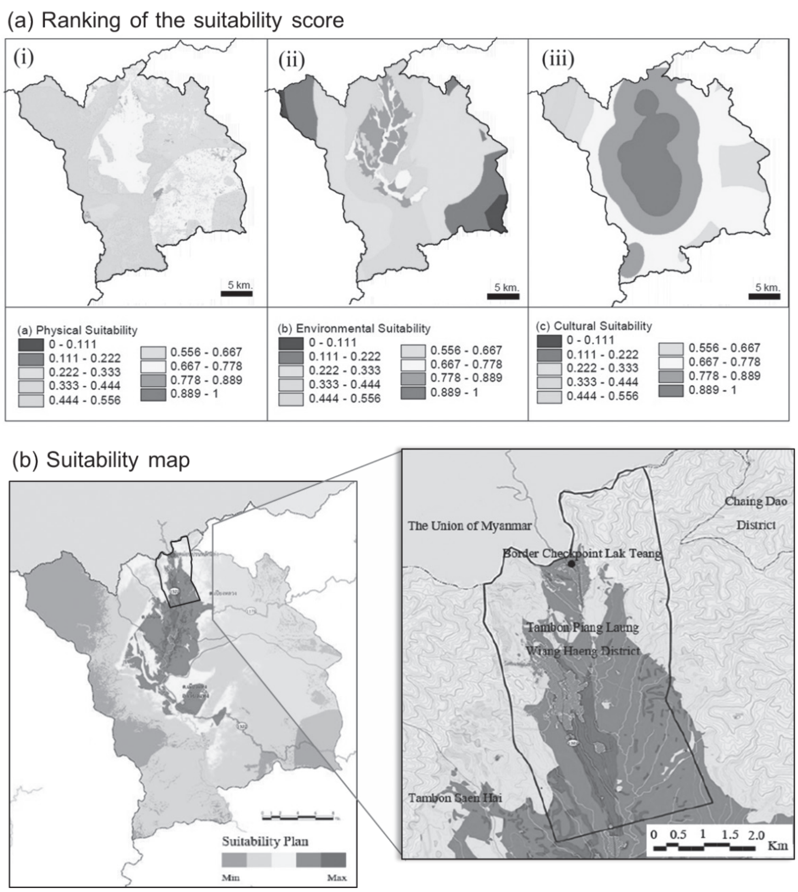


Figure 8. Evaluation criteria of land-use suitability

Figure9. Focus group meeting process allows participants interacting with Geodesign Technology. (Author, 2016)



Figures 10. Ranking of the suitability score for affecting land-use decision-making in the planning process

The meetings were convened and facilitated by the authors and included presentations by the conveners and other experts, including those from the participant group. Small and large group discussions were integrated into each meeting, with substantial opportunities for interaction among participants. In the following sections, LUSA as a way to support decision-making is introduced, and the conceptual framework is proposed and described. Then, a completed case study is presented to show the validation of this proposed framework. Finally, the advantages and the significance of this framework and its contributions to both academic and practice are discussed.

3. Findings and Outcomes of the Geodesign Framework

According to the survey of opinions of people and organizations related to Lak Tang Border Community Development Project in Public meetings, most of the attendants required urban plan which emphasizes economic development while simultaneously preserving watershed forest regarded as the important natural resources of border checkpoint area. The community groups also proposed to build a new Piang Luang Bypass Road essential in preventing traffic congestion in the area. In determining the role and vision for the project area, it involves "*development which conveys community towards a border trade community and tourism preserving uniqueness of local folk arts and culture and enhance community living surrounding plentiful watershed forest and sustaining their lives with holistic organic farming supported jointly with eco-cultural tourism for additional earnings*". The master plan designates development goals within 20 years (Figure 11a.). Each goal includes;

- First, the aspect of land use that focuses on land use designation which facilitates border trade while conserving quality agricultural lands. This can reduce the conflicts between community activities and sprawling of buildings;

- Second, urban environment aspect with the targets of increasing number of old buildings conservation and rehabilitation and improving the image of the city due to unplanned buildings and advertisements;

- Third, the aspect of population and society with increasing average educational level of population, lessening levels of immigration, more community participations and volunteers, and decreasing the trend of land sales;

- Fourth, the aspect of natural resources and environment that targets to increase a number of abundant forest areas, to reduce flood risks and decrease problems of lack of water supply in dry season, and to improve the quality of public watercourses.

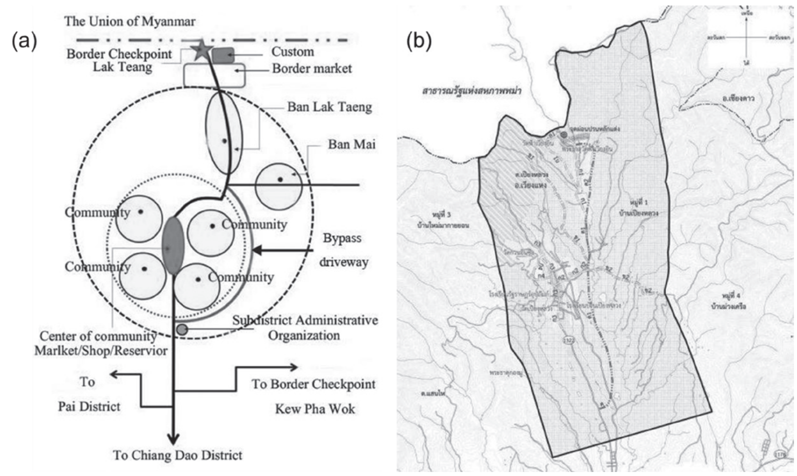
- Fifth, the aspect of economic with raising net household income, revenue distribution in the community and agricultural product exports;

- Sixth, the aspect of agricultural by enabling net increase in farmers' income and savings in corporation bank, decrease in imports of agricultural products and chemicals as well as farmer cooperatives;

- Seventh, the aspect of tourism with a higher number of well-maintained tourist attractions, distribution of visitors in other areas, average length of stay, and continually making greater net income of local tourism businesses;

- Last, the aspect of infrastructure, public utilities and transportation which orderly flow traffic volume in the city, reduction of driving accidents and vehicle fuel rates, greater number of households which can access standard electricity and water supply, access to sanitary waste disposal, and increase green areas, parks and sport activity areas.

Draft Project Plan of Lak Tang Border Checkpoint determines 11 types of land use zones such as (Figure 11b.);



Figures 11. (a) Final conceptual plan and (b) the comprehensive land-use plan of the Lak Tang border town. (Author, 2016)

- Low Density Residential Zone, surrounding Ban Piang Luang and Ban Lak Tang Communities with low population and building densities. This zone is planned to serve the expansion of the potential area and the trend of higher growth rate in the future;

- Low Density Residential Zone, surrounding Ban Piang Luang and Ban Lak Tang Communities with the strict land use regulation in order to efficiently preserve natural resources and environment as well as cultural heritage of the community;

- Middle Density Residential Zone, connected to the community hub and the quality residential zone that is expected to serve population and building expansion in the future. It is also planned for infrastructure development that would be sufficient to meet the future needs;

- Business and Commercial Zone, as the original commercial hub of Ban Piang Luang community to provide service to surrounding communities. The initiative involves enhancing this area to increase higher density land use with intensive commercial activities. In addition, it includes the control of other activities incompatible with high-density commercial and residential districts;

- Business and Commercial Zone, serving border trade activities that have commodity exports and imports. So, it is necessary to prepare the area for such activities in order to support and provide opportunity for local people and neighboring areas. Also, this can encourage international businesses both retailing and wholesaling as well as the positive impacts on investment and tourism sectors.

- And the other zones, regarded as the main components of the project plan including the government zone, the public utility zone, the educational institution zone, the religious zone, the rural and agricultural zone, the entertainment zone, the environmental conservation zone, and the forest preservation zone.

Following from the mixed method research design outlined above, the findings include outcomes relatively to the framework for Geodesign, and its intersection with perceptions of multifunctionality in land-use planning. In this study, a practical framework for Geodesign process was conducted to validate the effectiveness of the framework based on the feedback of experiencing the supported planning process from experienced planning practitioners the findings from the results of content analysis of the meeting transcriptions (to provide for deeper interpretation of collaborative Geodesign outcomes) are presented. The feedback showed that the experts gave positive comments to the framework for Geodesign and agreed that the planning process supported by the framework could facilitate the land use decision-making process in the comprehensive planning project. At the same time, the integrated whole of the collaborative Geodesign approach can be assessed relatively to the impacts of participants' perceptions of their collaborative work experience.

4. Conclusions and Discussion

Several new planning approaches such as scenario planning, public participation, and collaborative interaction are included in this framework to improve planning processes by enhancing their adoption and application in urban land-use planning. This proposed Geodesign framework is found to be a useful instrument for both practitioners and researchers involving sustainable land use planning in border town development. The LUSA model is the core of the framework. The land-use suitability map for land use types can be generated from this model. The model serves as a planning-support tool for the land use planning by quantitatively analyzing land-use suitability to assist planners in making land-use decisions for land zoning and development and explicitly conveying the planning principles from the perspective of planners to the public (nonprofessional stakeholders in planning) for improving the effectiveness of public consultation. Land-use suitability maps can also be used as the medam with GIS visualization for enhancing the communication between planners and other stakeholders involving the process of land use planning.

Although there are many advantages for applying this framework to land use planning practices, the framework still has one important limitation. Not all factors identified in the framework are quantitatively examined in the case study of Ban Lak Taeng because of the constraints of spatial data availability and techniques of criterion quantification (for example, neighborhood conditions associated to people (i.e., socioeconomic/cultural parameters) such as income, education, and customers which have not yet to be included in the study. However, these limitations do not invalidate the novelty and the contribution of this study. As an exploratory study, the results of LUSA based on the 20 available spatial criteria are appropriate, albeit not ideal, and the case study serves as an experimental implementation for validating the framework. At the same time – such as this study, the number of participants was relatively small and the participation of individuals varied somewhat across the focus group meetings, thus pre-post statistical tests of practitioners' feedback in perceptions across meetings cannot be applied. Recommendations for further development to explore stakeholders' perceptions of assessment feedback within the group meetings that can be qualitatively assessed, such as open-ended responses from surveys, meeting transcriptions, and notes from small and large group discussions.

Moreover, the methodological and data collection structures of this study could be informative and potentially replicated in future studies of processes that involve larger community groups or perhaps multiple stakeholder groups working in different contexts. As the framework for Geodesign continues to evolve and become more visible, it is essential to generate empirical studies that document its impacts. The authors firmly believe that advanced technologies such as 3D-visualization, web-based communication, and virtual-reality interaction could be adopted in supporting sustainable land use planning, particularly land-use decision making for land redevelopment/urban renewal in the future. This study helps contribute a small step forward in this direction.

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